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COMPLETE SPECIFICATION

Improvements in or relating to Hydrodynamic Coupling

We, BORG-WARNER CORPORATION, a corporation organised under the laws of the State of Illinois, United States of America, of 310, South Michigan Avenue, City of Chicago, State of Illinois, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to hydrodynamic coupling devices.

Hydrodynamic coupling devices of the type to which this invention relates comprise a rotating vaned pump or impeller forcibly transmitting liquid to a vaned turbine or runner to effect rotation thereof, the impeller being connected to a source of power, such as an engine, and the runner being connected to a work-performing member. In the event torque conversion is desired, at least one further vaned member acting as a reaction member is interposed between the impeller and runner to control the flow of the liquid from the runner to the impeller. The impeller and runner each include spaced semi-toroidal annular members, respectively known as the casing and the core ring, and vanes extending therebetween and forming passages therewith for the liquid, the impeller and runner being closely adjacent to each other but separated by a small gap so that their passages provide a substantially continuous path for the fluid circulated therethrough by the action of the vanes.

During the operation of such hydrodynamic coupling device, considerable fluid pressure exists in the liquid circuit of the impeller and runner, and this pressure will tend to move the impeller and runner away from each other and thus to increase the gap between the inlets and outlets of the passages of the impeller and runner. It is important that the inlets and outlets of the passages of the impeller and runner should be maintained as close as practicable, in order to prevent the escape of fluid circulating in the runner and impeller, which would result in shock and turbulence losses that would affect the torque carrying capacity and efficiency of the fluid coupling device.

On the other hand, it has been recognized to be desirable to provide some means permitting axial expansion and contraction of the enclosure for the fluid, so as to afford an opportunity to the device to yield axially as the pressures within the device increase with increasing speeds; and that this is particularly desirable where considerable heating up of the device is to be expected, as where the fluid space between the coupling members is sealed and the fluid is not continuously renewed.

A hydrodynamic coupling is known in which the impeller and runner elements are surrounded by a shell filled with the pressure fluid and having one of its axial end walls arranged so that it can yield axially when the shell expands, for example upon heating and/or due to internal pressures. In this prior device, thrust bearings are mounted on the driven shaft in a position to engage the hubs of the impeller and runner elements and to prevent these elements from moving axially away from each other. This arrangement has the disadvantage that any axial unbalance of fluid pressures in the shell produces an axial thrust on the driven shaft, which thrust is thereby transmitted to the exterior of the coupling.

The present invention solves the problem of maintaining the close spacing of the impeller and runner elements while nevertheless, permitting axial expansion and contraction of the device in response to variations of the fluid pressure therein, without transmitting any thrust to the exterior of the coupling.

To this end, the present invention provides a hydrodynamic coupling device including vaned impeller and runner elements arranged side by side for rotation

about a common axis with the vanes of said elements being effective to circulate fluid within said elements upon rotation of the impeller element; and a shell forming a closed fluid chamber around said vaned elements, an axial end wall of said shell being flexible to permit expansion and contraction of the fluid chamber by variations in the pressure of the fluid in the chamber externally of the vaned elements, the vaned element located adjacent to the flexible end wall being fixed at its outer circumference to a peripheral portion of the shell but being freely axially movable at its hub relative to the driven shaft, and the other vaned element being supported by the opposite axial end wall of the shell against movement away from the first mentioned element, whereby any tendency of the elements to be moved axially away from each other by internal fluid pressures is largely counteracted by the pressure of the surrounding fluid in the chamber and any resultant unbalance in axial fluid pressures is taken up by equal, oppositely directed forces in the shell walls.

Although the invention is applicable to hydrodynamic couplings regardless of whether they are or not of the torque-converting type, and regardless of whether they have a definite amount of fluid sealed therein or whether the fluid is continuously renewed by means of an extraneous pump or the like, the invention will be hereinafter particularly described as applied to a torque converter of the last-mentioned nature.

The accompanying drawing illustrates by way of example, in an axial section, one embodiment of the invention as applied to a torque converter.

The hydrodynamic coupling device illustrated comprises a pump or impeller element 10, a turbine or runner element 11, and two reactor elements 12 and 13. These elements are preferably formed of sheet metal.

The pump or impeller 10 comprises an annular semi-toroidal hollow casing 14, a semi-toroidal core ring 15, and a plurality of curved vanes 16 with the outer and inner arcuate edges of each vane connected by any suitable means, such as by welding, to the casing 14 and to the core ring 15 respectively to provide a plurality of fluid passages in the impeller 10. The turbine or runner 11 comprises an outer casing 17 connected to a core ring 18 by a plurality of curved vanes 19 attached to the casing and core ring and defining therewith a plurality of fluid passages. Disposed between the radially inner ends of the runner 11 and impeller 10 are a pair of reaction members 12 and 13, the reaction member 12 comprising an annular element 20 and a radially outer ring 21 connected by vanes 22, and the reaction member 13 having an annular element 23, a radially outer ring 24 connected by curved vanes 25.

A drive shaft 26 connected to any suitable source of power, such as an engine, is bolted at 27 to a drive plate 28 connected by bolts 29 to an annular sheet metal shell 30 formed as a dished stamping. The casing 14 of the impeller 10 is welded at its radially outer periphery to the shell 30 as indicated at 31, so that rotation of the drive shaft 26 will rotate the impeller 10. The shell 30 and the drive plate 28 define a fluid chamber 32 enclosing the vaned elements 10, 11, 12 and 13.

The manner in which the fluid under pressure is supplied to chamber 32 does not form part of the present invention. The fluid may, for example, be fed by an extraneous pump (not shown) into the annular passage 70 whence it passes through an aperture 42^1 in a stationary sleeve 42 into a space 34 hereinafter referred to in greater detail. Through an opening 14^1 in the impeller casing 14 the fluid reaches the interior of the space defined by casings 14 and 17 and fills the passages of the various elements and the space 35 between rings 15, 18, 21 and 24. Fluid also leaks into the space 33 to the left of the runner casing 17. A return conduit for the fluid, which is continuously renewed by the above-mentioned pump, is diagrammatically indicated by an opening 28^1 in the plate 28, a shallow space 26^1 and an axial bore 37^1 in a shaft 37, flow to this bore being controlled by a spring-pressed check-valve diagrammatically indicated by the ball 71, so as to maintain the device filled with the fluid at all times.

Upon rotation of the impeller 10, the vanes 16 thereof will forcibly urge the fluid in the impeller radially outward and into the passages of the runner 11 and against the curved vanes 19 of the runner 11, the fluid flowing radially inward through the passages of the runner 11 and into and through the passages of the reaction members 12 and 13, and thence back into the passages of the impeller.

The runner 11 is drivingly connected to a sleeve shaft 36 surrounding the shaft 37 which has its front end splined to the plate 28 and serves to drive transmission elements not involved in the present invention. The connection of the runner with sleeve shaft 3 is provided by a conical ring 38 welded as at 39, to the casing 17 of the runner 11, and secured to a hub 40 splined at 41 to the

sleeve shaft 36. This hub engages a thrust washer 40A bearing against the plate 28, whereby the runner is supported against movement away from the impeller 10. The shell 30 and the casing 14 of the impeller 10 have their radially inner edges rotatably mounted upon the stationary sleeve 42, which is bolted at 43 to a housing 44. The annular members 20 and 23 of the reaction elements 12 and 13 are secured as by welding to respective hubs 45 and 46 surrounding the stationary sleeve 42, with sleeve bearings 47 and 48 disposed between the hubs and the stationary sleeve 42. Thrust washers are respectively disposed between the hubs 40 and 45, between the hubs 45 and 46, and between the hub 46 and the impeller casing 14. One-way brakes 49 and 50 are provided between the hubs 45 and 46 and the stationary sleeve 42.

The described hydrodynamic torque-converter operates in accordance with well-known principles. The impeller 10, which is driven by the drive shaft 26, causes the fluid therein to be directed and impinge on the curved vanes of the runner 11 and causes the latter to start rotating in the same direction as the impeller 10. The torque on the runner is greater than the torque applied to the impeller due to the action of the reactors 12 and 13 which are held against rotation by the brakes 49 and 50. After the speed of the runner has reached a predetermined value, depending upon the load on the runner, the reactor members 12 and 13 will begin rotating in a direction releasing the one-way brakes 49 and 50, and the torque converter will then function as a simple fluid coupling or clutch, with the runner being driven at substantially the same speed as the impeller.

In hydrodynamic coupling devices of the torque-converting type described, as well as those devices consisting of only an impeller and runner and acting as a fluid clutch, it is of paramount importance in order to obtain maximum efficiency that the vaned elements be maintained as closely as possible to each other during operation of the device, as any substantial spacing of the elements from each other will disturb maximum fluid flow through the vaned passages of the elements by permitting the circulating fluid to by-pass the fluid circuit into the space between the core rings, and to escape into the surrounding space through the gaps between the vaned elements, resulting in shock losses and low torque efficiency of the device. Accordingly, it is necessary that the vaned elements of the coupling be positioned as closely as possible to each other in order to minimize by-passing or short-circuiting of the circulating fluid and to obtain maximum efficiency of the fluid coupling.

In the hydrodynamic coupling device, as shown in the drawing, it has been found that definite pressure exist in the space 33 between the drive plate 28 and the runner 11, in the space 34 between the impeller casing and shell 30, and also in the space 35 between the core rings 15 and 18 of the impeller and runner elements. If no pressure existed in the spaces 33 and 34, an axial thrust would be produced by the liquid in space 35 and in the vaned elements, tending to separate the impeller and runner and to widen the gaps, such as the gap between the entrance and exit passages of the impeller and runner. This condition is particularly aggravated in the case of a torque converter in which the curved blades of the impeller and runner cooperate with the curved blades of the reactor or reactors to increase torque, creating substantial greater pressures in the converter than in coupling devices consisting only of an impeller and runner.

The present invention has the considerable advantage of partially equalizing the pressures of the fluid in the fluid coupling device so as to minimize the axial thrust heretofore encountered, tending to separate the runner and impeller from each other. It may be noted that the shell 30 is welded at 31 to the casing 14 of the impeller 10, and that this is the only connection between the shell 30 and the casing 14, so that the radially inwardly extending portion of the shell, adjacent to the impeller casing and defining therewith the fluid-filled space 34, is free to expand and contract under fluctuating increasing and decreasing pressures of the fluid in the space 34. The runner 11, on the other hand, is supported at 40a against movement away from the impeller. By providing the spaces 33 and 34 into which fluid under pressure can seep and thereby counteract the pressure in the vaned elements and in space 35, axial movement of the impeller and runner away from each other is impeded. Any resultant unbalance in axial fluid pressures in the various parts of chamber is taken up by equal, oppositely directed forces in the shell wall. Nevertheless, the casing 30 is free to expand and contract because of the varying fluid pressure in space 34 which, of course, is larger than the aid pressure acting on the outside of the casing 30. Although the inner end of the impeller casing is not mechanically restrained against movement to the right, the pressure in chamber 34 opposes such movement so that the impeller will not

be axially moved away from the runner and reactors but will be maintained in close proximity thereto, even during expansion and contraction of the shell 30 for the purpose described. The shell 30 is formed of sheet metal of sufficiently light gauge to permit flexing of the radially extending portion thereof.

For the purpose of preventing leakage between the inner peripheral edge of the shell 30 and the stationary sleeve 42, an annular sleeve bearing 54 is fixed to one side of said edge, and an annular seal ring 55 received within a groove 56 of the stationary sleeve 42 abuts the sleeve 54. In addition, a seal ring 57 is disposed between the sleeve 54 and an annular boss 58, integral with the stationary casing 44. This arrangement permits axial movement of the radially extending portion of the shell 30 in either direction while effectively preventing the escape of fluid from the fluid chamber 32. The thrust washers need not have considerable capacity inasmuch as there is little or no axial thrust imposed upon them by the vaned elements of the described torque converter, and this would be equally true in the event of thrust washers between the hubs of an impeller and a runner utilized in a fluid coupling consistently only of such two vaned elements.

It may be noted that the core ring 15 of the impeller 10 and the core ring 18 of the runner 11 have their radially inner ends 59 and 60 extended and overlapping the radially outer annular rings 21 and 24 of the reactors 12 and 13, respectively, to prevent undue escape of the circulating fluid into the space 35 during passage of the fluid from the runner 11 to the reactor 12 and from the reactor 13 to the impeller 10 during operation of the torque converter. This arrangement is of value in confining the maximum flow of fluid within the stators and the runner and impeller.

It will be apparent from the foregoing description that we have provided an improved hydrodynamic coupling device, with one of its distinctive features being the utilization of hydraulic means for preventing separation of the vaned elements thereof from their close proximity to each other by the axial thrust imposed by the circulation of the fluid in the coupling device, insuring maximum efficiency of the device. While the invention has been particularly described and shown with respect to a fluid coupling device of the torque-converting type, the invention is equally applicable to fluid couplings forming a fluid clutch and consisting only of vaned impeller and runner elements. It will be further obvious that the invention is applicable to torque converters utilizing one or more impellers, turbines and reaction members.

What we claim is:—

1. A hydrodynamic coupling device including vaned impeller and runner elements arranged side by side for rotation about a common axis with the vanes of said elements being effective to circulate fluid within said elements upon rotation of the impeller element; and a shell forming a closed fluid chamber around said vaned elements, an axial end wall of said shell being flexible to permit expansion and contraction of the fluid chamber by variations in the pressure of the fluid in the chamber externally of the vaned elements, the vaned element located adjacent to the flexible end wall being fixed at its outer circumference to a peripheral portion of the shell but being freely axially movable at its hub relative to the driven shaft, and the other vaned element being supported by the opposite axial end wall of the shell against movement away from the first mentioned element, whereby any tendency of the elements to be moved axially away from each other by internal fluid pressures is largely counteracted by the pressure of the surrounding fluid in the chamber and any resultant unbalance in axial fluid pressures is taken up by equal, oppositely directed forces in the shell walls.

2. A device according to Claim 1, wherein part of said shell is in the form of a dished stamping of annular form defining with the exterior of said impeller element a fluid pocket, said stamping having its radially outer periphery secured to the radially outer periphery of said impeller element and having a flexible radially extending portion deformable in the axial direction by differences in fluid pressure in said fluid pocket.

3. A device according to Claim 1 or 2, wherein each of said elements comprise a hollow, annular, substantially semi-toroidal casing, a plurality of vanes within and connected to said casing, and a substantially semi-toroidal core ring within said casing and connected to said vanes, said vanes defining a plurality of fluid passages in each element with the fluid passages in one of said elements communicating with those in the other elements to provide circulation of fluid between the elements during rotation of said impeller; said core rings defining a fluid-filled chamber therebetween, said shell being connected at its radially outer periphery to said impeller casing and having a radially extending flexible portion movable axially by variations in fluid pressure in

said shell, said fluid pressure in the shell counteracting the fluid pressure in the space between said core rings and thereby opposing relative axial movement of said impeller away from said runner during operation of said device.

4. A device according to Claim 3, including at least one reactor element comprising spaced annular members and a plurality of curved vanes connecting said annular member and defining fluid passages, said reactor element or elements being disposed between the radially inner portions of said impeller and runner elements, the radially outer one of the annular members of the or each reactor element cooperating with said core rings of said impeller and runner elements in defining said fluid space between said impeller and runner core rings.

5. A device according to any of the preceding claims, wherein said shell comprises an annular, hollow, semi-toroidal sheet metal member surrounding the driving shaft of the device and connected at its radially outer periphery to a drive plate rotatable with said shaft, said shell being connected to the radially outer periphery of said impeller, said sheet metal member and said drive plate together defining the fluid chamber in which said elements are disposed, said member being spaced axially from said impeller radially inward of its connection to said impeller and being capable of flexing to contract and expand as a result of said pressure variations.

6. A hydrodynamic coupling device constructed and adapted to operate substantially as herein described with reference to the accompanying drawings.

STEVENS, LANGNER, PARRY & ROLLINSON,
Chartered Patent Agents,
Agents for the Applicants.

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730,857 COMPLETE SPECIFICATION
1 SHEET

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